Master Drainage Study
Grand Canyon High School
Project Understanding

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Nomenclature

GCHS – Grand Canyon High School

USGS – United States Geological Survey

1.0 Introduction

Grand Canyon High School is in need of a master drainage system. The current drainage infrastructure is dramatically inadequate and will lead to failure of walkways and foundational edifices. The purpose of this project is to assess the demands and criteria for a safe hydraulic scheme and to design an adequate system for Grand Canyon HS.

2.0 Background Information

The following background information has been collected regarding location, current infrastructure, problem areas, hydrological data, and regulations.

2.1 Location

Grand Canyon High School is located at 100 Boulder St, Grand Canyon Village, AZ 86023. The campus lies within Grand Canyon National Park and, as such, must follow the corresponding guidelines. The geographical location of Grand Canyon Village is shown in Figure 1.

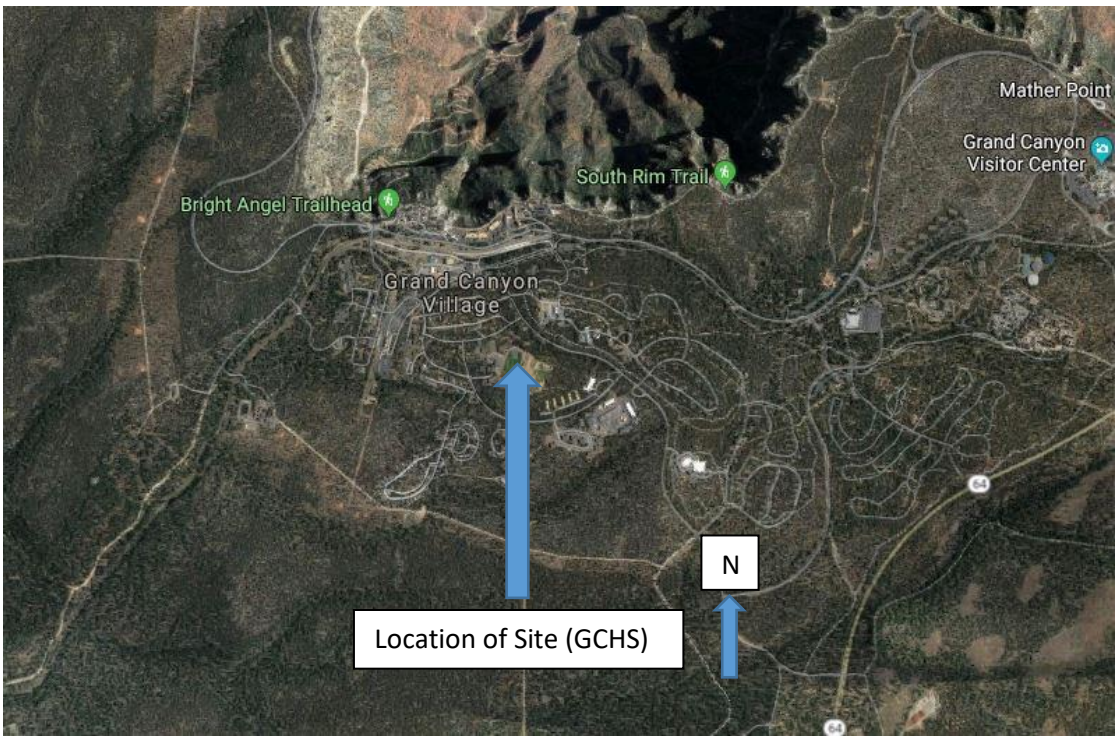

Figure 1: Aerial Map of Grand Canyon Village, Arizona [1]

Figure 2 shows the campus layout of GCHS [1].

Figure 2: Aerial View of Grand Canyon HS campus, Arizona [1]

2.2 Current Infrastructure

The current infrastructure consists of fairly primitive design aspects as a result of aesthetic restrictions and poor planning. Several small culverts, such as Culvert A in Figure 3, are located throughout the campus.

Figure 3: GCHS culvert A

Open channels with natural bedding are currently used to divert water away from structures. Figures 4 and 5 depict the state of such open channels.

Figure 4: GCHS channel A, bottom view

Figure 5: GCHS channel A, top view

Additional images of Grand Canyon High School campus and the current hydraulic infrastructure are located in Appendix A.

2.3 Areas of Concern

The following areas of concern associated with this project will be addressed in the following sections.

2.3.1 Culvert B

Culvert B has proven to be inadequate with regards to expected volumetric flow. As seen in Figure 6, Culvert B passes underneath a walkway and surfaces parallel to another walkway.

Figure 6: GCHS culvert B, problem area 3

2.3.2 Foundation A

Figure 7 shows an area where surface runoff is passing beneath a structure. The flow of runoff beneath the structure is causing erosion and damage to the foundation.

Figure 7: GCHS foundation A, problem area 4

2.3.3 Precipitate Aggregation

The roof of Building A, due to encompassing a vast area, catches a large volume of rainfall and pitches the fluid off to one side. As seen in Figure 8, the topsoil is at a higher elevation than the ground floor of the building. Surface runoff flows toward the building, inundating doorways and flooring with the captured rainfall.

Figure 8: GCHS Building A, problem area 5

2.4 Hydrological Data

According to the Arizona Water Atlas, Grand Canyon National Park receives an average annual precipitation is 25.8 inches [2]. The Grand Canyon Village has an average annual evaporation rate of 44.04 inches [3]. According to a hydrological study of the Coconino Plateau by USGS, Grand Canyon Village is located on a Kaibab formation exhibiting a typical infiltration of 0 to 0.5 cm per hour [5]. Precipitation frequency data for Grand Canyon Village [3] is located in Table 1, Appendix B. Figure 9 shows the watershed connected to Grand Canyon High School.

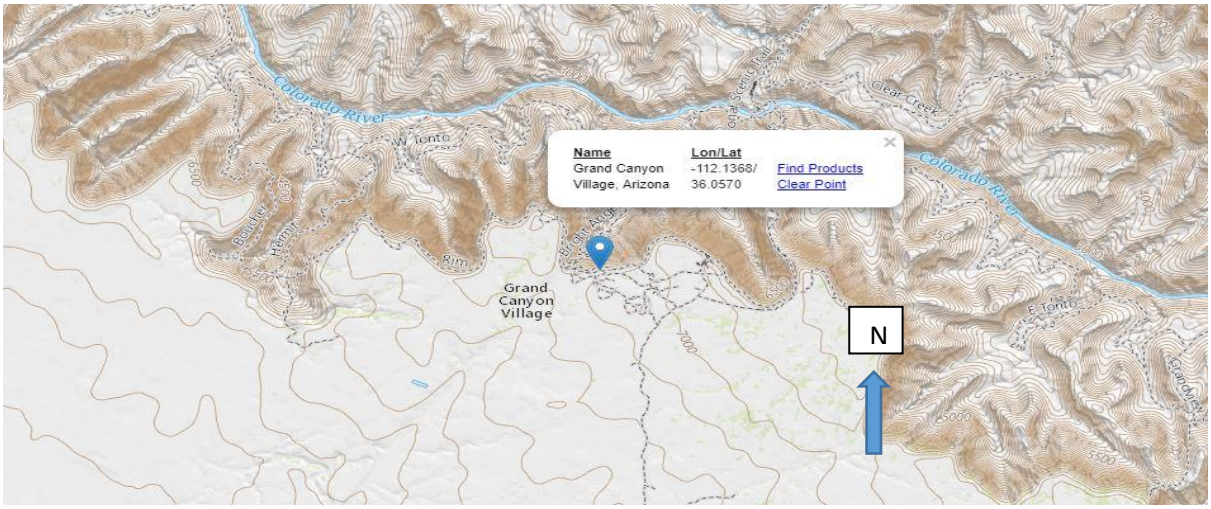

Figure 9: USGS Contour and Watershed map for location of interest - GCHS [4]

2.5 Regulations

GCHS resides within Coconino County, and within a National park. Careful consideration of federal, county, state, and all other regulations must be taken at all times. Some of the federal regulations that need to be considered include but are not limited to:

- Title 49 chapter 2 "Water quality control" [6]
  - Federal water quality standards regarding pollutants, discharges, etc.
- Title 49 chapter 8 " Water infrastructure program" [6]
  - Federal design standards for basic water infrastructure
- Title 45 chapter 8 " Flood Control" [7]
  - Federal design standards for flood management, reuse, and rerouting of storm water.
- Coconino County Engineering and Construction Criteria Manual [8]
  - Aids in identifying the laws of Coconino County, its political subdivisions, and the State of Arizona in general.
- Coconino County meets the minimum federal requirements for designation by the United States Environmental Protection Agency (EPA) as a Small Municipal Separate Storm Sewer System Operator. [9]

3.0 Technical Considerations

The following technical considerations will be implemented for the completion of this project.

3.1 Hydrology

Hydrology is directly concerned with the properties of water and how it interacts with land. This can include surface runoff, infiltration, evapotranspiration, and groundwater flow. With a low volume system, there is little treatment required for storm water drainage. Typical screen and basin percolation is commonly practiced. Storm water detention sites, low-impact development basins, and other structures will need to be identified and evaluated for volume and retention time. Continuous testing may be performed to ensure safety of downstream consumers, if applicable.

3.2 Surveying

An accurate survey greatly aides in the creation of viable models and maps. Some of these maps include site topographic and problem area locations. New survey technology allows for aerial mapping with lidar that can create digital terrain models. Surveying will be conducted with a Total Station. Data will be collected and saved in Excel spreadsheet. Evaluation of elevation points and terrain simulation will be conducted using Civil3d.

3.3 Hydraulics

Hydraulics concern the use of mechanical force or gravity to convey water through open channels. A proper hydraulic system will safely transport the required flow without failure. Safety factors, friction losses, total energy and cavitation problems are analyzed

independently during the design phase. Total surface runoff will be calculated and extrapolated through available precipitation, evaporation, and infiltration data. Expected volumetric flow rate for each area will be established. HEC-RAS will be used for the design of channels and pipe selection. Bentley systems such as StormCAD, CulvertMaster, and FlowMaster will be utilized to model flow and test performance of proposed design.

4.0 Potential Challenges

Most projects require the aid of numerous contracts, companies, and overall bodies working in unison to be completed in an efficient manner. Potential challenges will always arise when there are so many pieces moving on the board that relate to one another. For the Grand Canyon High School project, some potential challenges will include historical preservation, evolving regulations, scheduling, and overall site restraints.

Historical preservation may prove to be the largest hurdle for this project. Any changes made to the current system cannot result in visually abnormal or displeasing structures. New designs must remain low key and rustic in style.

The Environmental Protection Agency is constantly monitoring, testing, and implementing new laws based on gathered data. Constant research must be done to ensure all laws, acts, and regulations are being met correctly. Obtaining the correct permits and meeting strict county and state regulations will ensure the safety and quality of the project and its affected community and stakeholders.

Preservation of storm water through newly proposed drainage system is a top challenge. Both the quantity and quality of the runoff need to be looked at very carefully at all stages of the project, including post-completion. The new system cannot increase concentrations of contaminants within the water being transported. Furthermore, updating the current infrastructure may require instruments to monitor the downstream storm water quality in an efficient manner.

Land constraints can directly affect storage facilities, construction, and plan design. Spatial coordination will be a priority. Geotechnical constraints can create potential challenges as well. Soil characteristics will dictate direction of project.

Scheduling conflicts may occur due to school schedules, both Grand Canyon High School and Northern Arizona University. Every effort will be made to coordinate between the needs and demands of both schools.

5.0 Stakeholders

The following stakeholders are directly affected by the project. The effects may be financial, societal, or environmental. Safety, wellbeing, concerns, and comments of the stakeholders will be considered throughout the duration of this project.

5.1 Ivan Landry

Ivan Landry is the Director of Maintenance, Transportation, and Operations at GCHS. Particularly, Mr. Landry is the client requesting the services described, the main contact for this project and chaperone for all site visits.

Contact: (928)638-2461
Email: ILandry@grandcanyonschool.org

5.2 Dave Mortenson

Dave Mortenson is the President of the Grand Canyon Historical Society which oversees preservation of historical attributes related to the vicinity. Visible alterations will need approval from the society panel.

Email: Secretary@grandcanyonhistory.org

5.3 Grand Canyon High School Students and Faculty

The students and faculty will be affected directly by any changes to the current infrastructure occurring as a result of this project.

5.4 Dr. Rochonne Bria

Dr. Rochonne Bria is the Superintendent for Grand Canyon High School. The superintendent leads implementation of school board decisions and makes direct decisions regarding spending, staff, and facilities.

Phone: (928) 638-2461

5.5 Kevin Hartigan

Kevin Hartigan is the President of the Governing Board of Grand Canyon Unified School District. The Governing Board determines policy, budget, and culture for incorporated institutions within the district.

Email: kthartigan@grandcanyonschool.org

5.6 Jeffrey L. Heiderscheidt, Ph.D.

Jeffrey L. Heiderscheidt, Ph.D. is the technical advisor for this NAU capstone team.

Phone: (928) 523-0501
Email: jeffrey.heiderscheidt@nau.edu

5.7 Paul T. Gremillion, PhD., PE

Paul T. Gremillion, PhD., PE is the Department Chair for Civil and Environmental Engineering at Northern Arizona University.

Phone: (928) 523-5382
Email: Paul.Gremillion@nau.edu

5.8 National Park Service

The United States Department of the Interior, National Park Service is in charge of Grand Canyon Village and liable for construction and renovation projects which may occur.

Phone: (928) 628-7888

References

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[9] "Coconino County Storm water Quality and Runoff Control Ordinance.", Coconino.az.gov, 2018. [Online]. Available: http://www.coconino.az.gov/DocumentCenter/View/18156. [Accessed: 14- Feb- 2018].

Appendix A

Figure 10: GCHS ponding area A, problem area 6

Figure 11: GCHS drainage tank / basin A, problem area 7

Figure 12: GCHS drainage tank / basin B, problem area 7

Appendix B

Table 1: Precipitation Frequency Data for Grand Canyon Village [3,5]

PRECIPITATION FREQUENCY ESTIMATES (in inches)[1]										
Average recurrence interval (years)										
duration	1	2	5	10	25	50	100	200	500	1000
5-min:	0.141	0.18	0.25	0.32	0.428	0.528	0.649	0.794	1.03	1.24
10-min:	0.214	0.273	0.381	0.486	0.652	0.804	0.988	1.21	1.57	1.89
15-min:	0.265	0.339	0.472	0.602	0.808	0.997	1.22	1.5	1.94	2.34
30-min:	0.357	0.456	0.636	0.811	1.09	1.34	1.65	2.02	2.61	3.16
60-min:	0.442	0.564	0.787	1	1.35	1.66	2.04	2.5	3.23	3.91
2-hr:	0.601	0.753	1	1.24	1.62	1.96	2.37	2.85	3.62	4.34
3-hr:	0.663	0.83	1.08	1.3	1.65	1.99	2.4	2.88	3.66	4.36
6-hr:	0.824	1.02	1.27	1.5	1.84	2.13	2.44	2.91	3.68	4.39
12-hr:	1.01	1.24	1.54	1.79	2.13	2.4	2.69	2.99	3.74	4.46
24-hr:	1.22	1.52	1.91	2.22	2.65	2.99	3.35	3.71	4.23	4.62
2-day:	1.41	1.76	2.21	2.57	3.07	3.47	3.89	4.32	4.91	5.38
3-day:	1.5	1.87	2.35	2.74	3.29	3.71	4.17	4.63	5.28	5.79
4-day:	1.59	1.99	2.49	2.91	3.5	3.96	4.44	4.95	5.64	6.2
7-day:	1.83	2.3	2.91	3.4	4.08	4.61	5.17	5.74	6.54	7.16
10-day:	2.02	2.55	3.26	3.83	4.63	5.28	5.95	6.66	7.64	8.42
20-day:	2.64	3.31	4.14	4.8	5.69	6.38	7.09	7.8	8.77	9.51
30-day:	3.19	4.01	4.99	5.76	6.77	7.53	8.29	9.05	10.1	10.8
45-day:	3.78	4.75	5.99	6.96	8.29	9.31	10.4	11.4	12.9	14
60-day:	4.35	5.47	6.92	8.07	9.63	10.8	12.1	13.4	15.1	16.4